GALLS OF AGROMYZIDAE (DIPT.) ON *PITTOSPORUM UNDULATUM* ANDR.

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(*Communicated by C. E. Chadwick.*)

(Plate ii; four Text-figures.)

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Synopsis.

Two new species of *Phytobia* (Agromyzidae) are described, one causing mine galls on the leaves, and the other galls on the stems of *Pittosporum undulatum*. Information is given on the bionomics and life-history of each.

Mr. C. E. Chadwick (Entomological Branch, New South Wales Department of Agriculture, Sydney) has for some years observed larvae in the leaves of *Pittosporum undulatum* Andr. He has collected the adults belonging to the larvae from the gall-like mines in the leaves and bred out flies from the twig galls which he found on the same plant. I acquired from him for study the material of flies, larvae and galls thus obtained. This showed that the flies belonged to a genus previously represented in Australia by only a single species. I am much obliged to Mr. Chadwick for sending this material, and also for his exceedingly careful observations on the life cycle and habits of these pests on *Pittosporum*.

To my great surprise this material from *Pittosporum* proved to consist of two different but quite closely related species which may be easily distinguished in the adult, and still more easily in the larvae and the galls produced by them. Both are new to science and are to be described below; the species of which the larva lives in mine-like galls on the leaves will be named *Phytobia* (*Praspedomyza*) *pittosporophylli*; the one living in the twig galls will be named *Phytobia* (*Praspedomyza*) *pittosporocaulis*.

Phytobia (Praspedomyza) pittosporocaulis, spec. nov.

In this and the following species the orbits are not distinguished from the interfrontalia as a ledge, as should be characteristic of this subgenus according to Hendel, but even Hendel groups in this subgenus, species which do not show this character (or only when the frons is shrunken). I consider the possession of more than three bulbs on the posterior spiracles distinctive for this subgenus.

Head.—Frons longer than width above, narrowed anteriorly; distance between inner verticals as great as distance from inner vertical to base of antenna and one and a half times as great as distance between middle lower orbitals. Ocelli forming an equilateral triangle. Orbits not abruptly elevated next to the interfrontalia. Face at mouth margin one and a half times as wide as its height to bases of antennae. Parafacials, near bases of antennae, as wide as the first antennal segment, rapidly contracting below to a very narrow strip. Lunule narrow, arched somewhat higher than a semicircle. Facial carina narrow above, broadened and flattened below.

In profile frons and face visible in front of the eyes as a uniformly narrow ring. Face concave, mouth margin projecting. Ratio of vertical to horizontal diameter of eye 5:3. Width of cheek below the deepest part of the eye one-sixth, posteriorly one-fifth the vertical diameter of eye.

Bases of antennae closely approximated. Third antennal segment rounded, but distinctly widening and hatchet-shaped in front. Arista somewhat more than three times as long as the third antennal segment, quite shortly pubescent. Palpi cylindrical, proboscis widening and flattened at end.

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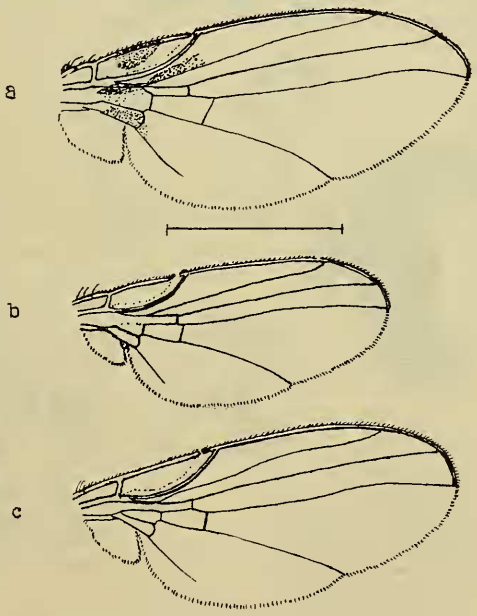
Chaetotaxy.—One or two superior orbitals, reclinate and often also slightly incurved. Three or four inferior orbitals, the foremost often weaker, sometimes absent on one side. Ocellars, if depressed, reaching to the first superior orbital. Orbital hairs dense, short, reclinate, in one row anteriorly, forming several rows in places posteriorly. One to three incurved vibrissae on the vibrissal angle, three or four upwardly and outwardly directed bristles on cheek margin.

Thorax.—3 + 1 dorsocentrals, the foremost on or very slightly in front of transverse line connecting the presuturals, third dorsocentral distinctly behind suture. Second dorsocentral more than twice as far from the first as from the third. Acrostichals very irregularly arranged in four to five rows, reaching anteriorly in front of the fourth dorsocentral and extending behind the first dorsocentral in still more rows. Intra-alar lines with eight to fifteen hairs in front of the suture and three to five hairs behind; intra-alar bristle absent. Humeral callus with three to five hairs. Inner post-alar one-third to one-half as long as outer post-alar. Posterior margin of mesopleuron with one mesopleural bristle and three to five hairs, without outwardly directed hairs below the upper margin. Sternopleuron with a small hair in front of posterior upper sternopleural. Scutellum with four subequal scutellars, dorsal surface with up to five small hairs.



Text-fig. 1. Wing of (*a*) *Phytobia pittosporocaulis* Hg. ♂; (*b*) ♂ and (*c*) ♀ of *Phytobia pittosporophylli* Hg. (⊢—⊣ = 1 mm.).

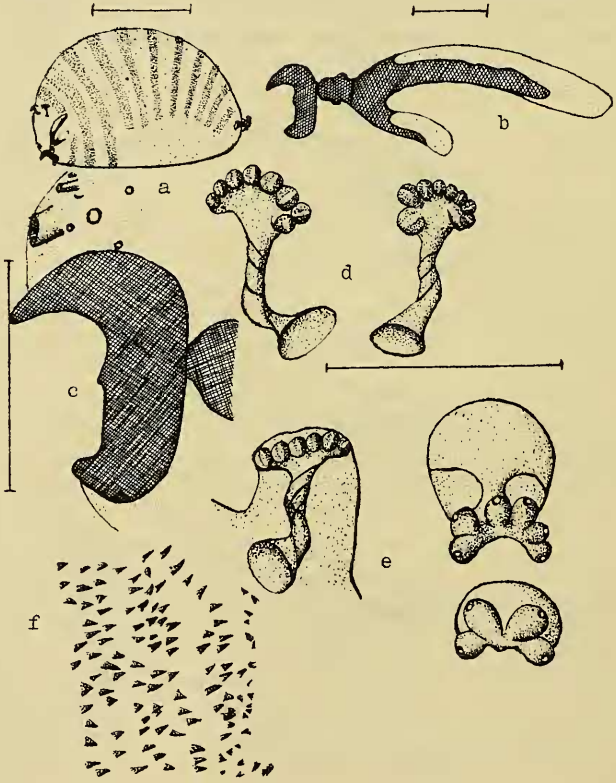
Abdomen.—Tergites with long bristles on their posterior margins. Last tergite of female more than twice as long as the penultimate. Ovipositor elongate-conical, as long as the last tergite. In the male the last tergite somewhat longer than the previous one. Hypopygium large.

Legs normal, mid-tibia without postero-dorsal bristles.

Wing (Text-fig. 1, *a*).—Costa reaching to the end of *m*. Proportions of costal sections 2:3:4 = 7:3:2 (= 45:17:12). R_{4+5} convex anteriorly, bending forwards at distal end; *m* bending posteriorly at end. *Cd* very short, last section of *cu* about $3\frac{1}{3}$ times as long as penultimate section, *ta* rarely in centre of *Cd*, usuallyl near *tp*, and below the end of r_1; form of *Cd* and position of *ta* very variable, *ta* and *tp* often extremely strongly

approximated, sometimes even one above the other. *an* not reaching hind margin of wing. Wing length $1\frac{3}{4}$ (♂) – $2\frac{1}{2}$ (♀) mm.

Coloration.—Interfrontalia light wax-yellow to dirty grey. Face deep black, only the mouth-margin narrowly edged with light yellow. Prelabrum and palpi black, proboscis light yellow. First antennal segment black, the second paler, the third predominantly yellow to reddish-yellow, the short hairs on anterior margin white. Arista black. Thorax black, mesonotum and scutellum entirely matt, with bluish-grey dusting; the lateral region not lighter, at most the sutural triangle somewhat paler. Humeral callus indistinctly yellowish posteriorly. Mesopleuron with narrow, light yellow margin above (and indistinctly so below). Sternopleuron completely black. Abdomen somewhat more shining, tergites very narrowly margined with yellow behind. Legs black, knee of fore-leg quite narrowly yellow. Wing glassy but Cc_2 shaded with grey. Squamae dirty white, with dark margins and fringe. Halteres yellow.



Text-fig. 2. *Phytobia pittosporocaulis* Hg., Larva: (*a*) Habitus, (*b*) Cephalopharyngeal skeleton, (*c*) Head region, (*d*) anterior and (*e*) posterior Spiracles, (*f*) lateral section of an abdominal band of cuticular processes (⊢⊣ in *a* = 1 mm., in *b-e* = 0·1 mm.).

Holotype ♂ and allotype ♀ from Normanhurst (New South Wales), bred from galls on *Pittosporum undulatum* Andr. on 28.ix.1956, in Department of Agriculture, Entomological Branch, Sydney (N.S.W.); paratypes: 4 ♂, 18 ♀ from the same locality, 19–28.ix.1956; 1 ♂, 2 ♀ from Sydney, 11.ix.1956, 1 ♂ from Seaforth, 31.vii.1957, all bred from twig galls. Paratypes also in British Museum (Natural History), London, and in the Zoologisches Museum der Humboldt-Universität, Berlin, and in the Australian Museum, Sydney.

Description of Larva (Text-fig. 2).

The larva is very different from that of the following species in a number of characters. Even in its external shape it is distinguishable from the second species described below in its more compact form (Text-fig. 2, *a*); and thus has the appearance of many true gall-makers among the dipterous larvae, in contrast with related species which do not live in galls. Cuticular processes absent in the head region above and also below the mandibles, but abundantly developed on the thorax and abdomen in annular bands of small teeth. The processes (Text-fig. 2, *f*) differ quite substantially from those of the following species. Whilst in *Ph. pittosporophylli* Hg. they are almost hemispherical and show a slight point, they are here long and sharp with slightly thickened basal part. The bands of the first two thoracic segments are not differentiated from those of the abdomen in the structure and size of the spines. Prothoracic band with a maximum number (dorsally) of 12 transverse rows of teeth, the foremost rows smaller; the band is broadest dorsally, interrupted laterally. Mesothoracic band complete, spines in 12–14 transverse rows. That of metathorax similarly formed but strongly narrowed ventrally. First abdominal segment with a similar band which is, however, broadly interrupted centrally. Band of second segment with only about eight transverse rows of spines and likewise interrupted ventrally. The following bands become progressively narrower and more widely open ventrally; the third to seventh segments still have bands which are continuous dorsally, and are only interrupted ventrally. The band of the eighth segment is only developed laterally, where it is strongly formed from six rows of spines. Anal field without spines.

Antenna slender, maxillary palp short but about three times as thick as the antenna. No frontal sclerite visible. In the cephalopharyngeal skeleton (Text-fig. 2, *b*) the labial sclerite is unusually short and thick. The dorsal process of the paraclypeal phragma is about three times as long as the ventral; its strongly sclerotized deep black coloured lower part is strikingly stouter than in the following species. Both processes are thicker than in *Ph. pittosporophylli* Hg. The mandibles (Text-fig. 2, *c*) have each only one tooth, below it a small prominence as the only vestige of the second tooth; on the lower margin they are produced into an orally directed projection. Both mandibles are equally long, their teeth not therefore alternating in position.

The anterior spiracles (Text-fig. 2, *d*) have six bulbs, which stand in an ellipse, which is open on the inner side. The atrium is narrow, winding, strongly thickened where it joins the trachea. The posterior spiracles (Text-fig. 2, *e*) have four to six bulbs, their atrium is relatively shorter, also winding, considerably thickened where joining the trachea.

Apart from the general shape of the body one can also immediately distinguish this species from the other by its pointed cuticular processes, the single-toothed mandibles and the small number of bulbs on the posterior spiracles.

The Gall (Pl. ii, fig. 1, 2; Text-fig. 3*a*).

The larva lives in twig galls (shoot-axil galls) of semi-ovoid or hemispherical shape on *Pittosporum undulatum* Andr., which may attain a diameter of 5·7 mm. and which gradually extend to the cortex (Text-fig. 3*a*). The gall always lies above a point where a leaf develops with a bud actually on it. A single larva inhabits each swelling. The gall may be up to three times as thick as the twig at the point of its development but is usually smaller. Often a number of galls develop in the same twig in close proximity and occasionally their edges overlap. At oviposition the egg is inserted beneath the epidermis; this point of oviposition appears later as a pale point on the gall. The adult larva later feeds up to the edge of the epidermis; at this point the epidermis is later burst open, and the gall-former emerges into the open.

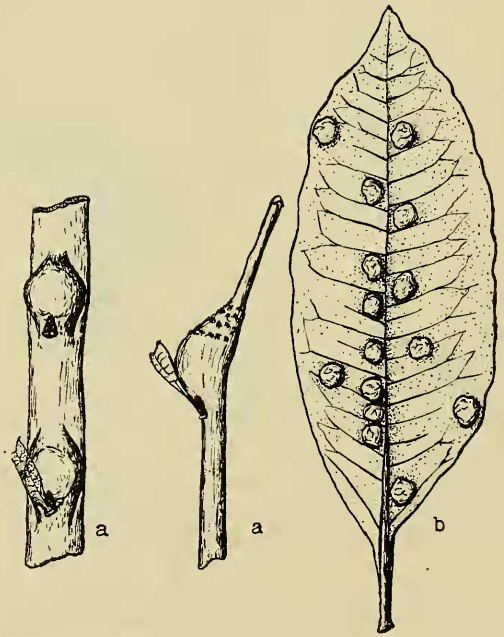
The gall formed in this way may be termed *histioid* (without organic formation) and *prosoplasmatic* (of definite size and shape). It can be classified as a hyperplasia, since it develops from increased growth and a frequent division of the cells. The larva

eats out channels in this gall-tissue of hyperplastic origin, which are concentrated in particular below the bud and finally form there a large cavity.

In the first feeding-stage the larva feeds exclusively on the parenchyma of the cortex. The cells of the cortical parenchyma rapidly increase in number and size under the influence of the gall-causing factors; they are the first food of the young larva. As a result of pressure the cells appear more cylindrical. Newly formed callus tissue penetrates into areas eaten out by the larva, the cells of which are more spherical, and they later entirely fill the feeding channel.

In the second phase the larva penetrates into the pericycle and feeds on its tissue. It feeds at the point where the fibro-vascular tissue of the leaf stalk joins the central fibro-vascular bundle, eating the outer tissues, especially parenchyma and phloem.

Plate ii, Figure 1 shows this point of junction, the "leaf-gap" of the central area, where the more strongly developed xylem is interrupted. After the larva has largely eaten this tissue, callus with large cells and delicate walls develops there; these cells are first arranged radially, but they are smaller and more regular than those formed by the phloem which is also eaten. The grains of frass are everywhere covered, enclosed and compressed in callus. Large, black grains of frass lie in the remaining area of the feeding channel.



Text-fig. 3. (*a*) Twig galls of *Phytobia pittosporocaulis* Hg., (*b*) Leaf with mine galls of *Ph. pittosporophylli* Hg. on *Pittosporum undulatum* Andr.

Although the larva first feeds only in the cortical parenchyma and in the following phase specializes in the pericycle, in the last phase of its feeding it no longer discriminates between the various tissues. The feeding channel now extends from the inner area of the fibro-vascular bundle-ring almost up to the epidermis, and substantial sections of the xylem are also eaten (constituent parts of this are still recognizable in the frass). In this way a large cavity is formed (Pl. ii, fig. 2), no longer filled with callus, probably because here the humidity of the air is too reduced, and also because the vegetation period of the plant is too far advanced and in consequence its capacity to react is too diminished. It is noteworthy that at no point is the central tissue

within the fibro-vascular bundle injured, and also the tissues immediately beneath the bud are left untouched.

From the position of the main feeding area at the junction of the central tissues of the mid-rib of the leaf with the central cylinder of the shoot, the larva obtains the maximum possible amount of nutritive elements.

PHYTOBIA (PRASPEDOMYZA) PITTOSPOROPHYLLI, spec. nov.

As this species is very similar to the one just described, it is necessary to mention here only the characteristics by which it differs from it.

Head.—Lunule broader, lower, approximately in the form of a semicircle. Frons pale yellow to leathery yellow. Only the first two antennal segments are bright yellow to yellowish-brown (rarely black); the third segment always deep black (except in specimens which are not fully pigmented). The rear two ocelli are further apart, the three ocelli form a triangle in front, with the apex of the triangle forming a right angle. Orbital hairs very sparse, in single row throughout.

Thorax.—The acrostichals arranged in only two rows, very regular, extending in front slightly beyond the fourth dorso-central, but ending behind at or slightly beyond the second dorso-central; they are somewhat longer than in the previous species. There are one to two intra-alar hairs before and behind the suture. The scutellum above always without hairs, apart from the scutellars.

Abdomen.—The last tergite of the ♀ is only 1½ times as long as the penultimate. Oviscape broad and short, equal in length to last tergite. In ♂ last tergite 1¼ times as long as the penultimate, the genital capsule smaller than in previous species.

Wing (Text-fig. 1, *b*, *c*).—The costal segments 2:3:4 are in the ratio of 3:1:$\frac{2}{3}$, the second segment is thus relatively shorter. The last segment of *cu* is about three times as long as the penultimate, the *Cd* is thus relatively shorter than in the previous species. The *ta* is usually closer to the *tp* in the ♂ than in the ♀. The blackish shading on the basal area of the wing which characterizes the previous species is here lacking. Wing length 1·7 (♂) – 2·2 (♀) mm.

♂-Holotype and ♀-allotype from Roseville (New South Wales), caught on 25.viii.1956 on young leaves of *Pittosporum undulatum* Andr.; 17 ♂, 12 ♀ paratypes from the same locality from 25.viii–2.ix.1956; 2 ♂, 4 ♀ from Hornsby, 2.ix.1956; all in Department of Agriculture, Entomological Branch, Sydney. Further paratypes: 15 ♂, 9 ♀ from Roseville, presented to the Commonwealth Institute of Entomology, London, and 15 ♂, 9 ♀ from the same locality presented to the Zoologisches Museum der Humboldt-Universität, Berlin, and 8 ♂, 4 ♀ from Roseville, presented to the Australian Museum, Sydney. The entire material was collected by Mr. C. E. Chadwick. 1 ♀ caught by Mr. F. Bagshaw on 6.ix.1956 at Normanhurst.

Description of the Larva (Text-fig. 4).

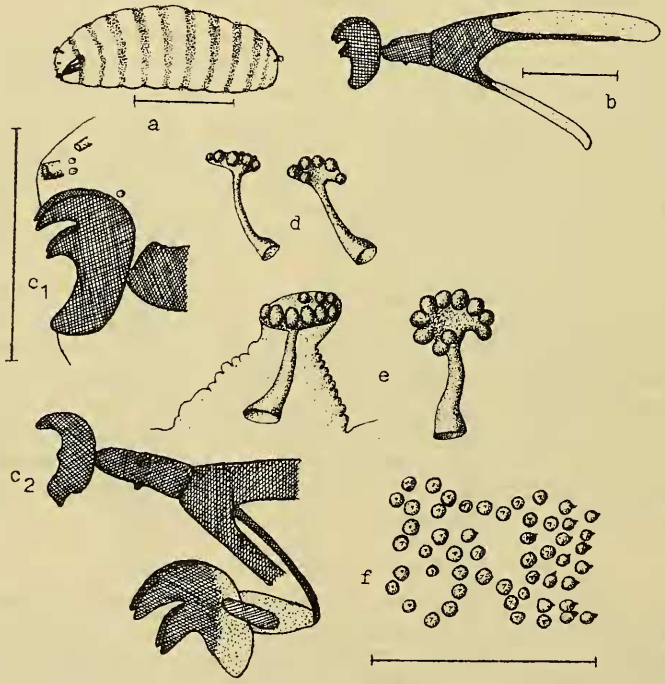
The larva (Text-fig. 4, *a*) is the normal shape of the majority of Agromyzid larvae. It is thus neither conspicuouly thin and elongated, nor is it noticeably short and thick. The cuticular processes used for movement (Wärzchen) are entirely absent in the region of the head, and also above and below the mandibles. On the prothorax there is an uninterrupted band of such processes which are arranged in 3–5 (ventrally only in 1–2) transverse rows. The band of the mesothorax is similar. On the metathorax there is a similar band with the processes in about six rows. On the first abdominal segment the band is somewhat broader, and the processes are irregularly in 8–10 rows; the bands on the second and sixth abdominal segments are similar. That of the seventh segment is narrower, and the processes are in only 6–7 irregular rows and are lacking on the dorsum, so that the band is interrupted above, while on all the previous segments it is entirely continuous. The last segment only has a small area with a few processes in the vicinity of the anal opening. All the processes are of similar shape and size (Text-fig. 4, *f*); they are roughly hemispherical and bear only the trace of a small

point, this being particularly clear in the hindmost transverse rows where the processes may also appear slightly smaller. It is noteworthy that the processes of the pro- and mesothorax are not smaller, as is usually the case in Agromyzid larvae.

Antennae slender, maxillary palps twice their thickness, the two varying little in length. A more strongly sclerotized frontal sclerite not apparent. On the cephalopharyngeal skeleton the shortness of the labial sclerite and the moderate development of the oral section of the paraclypeal phragma are very striking (Text-fig. 4, *b*). The dorsal process is about 1½ times as long as the ventral, and has entirely dark pigmentation only in the ventral areas; only the basal part of the ventral process is also entirely black. The lower arm of the dorsal process is vestigial. The mandibles have two teeth, the left one is only slightly shorter than the right and therefore the two pairs of teeth scarcely alternate (Text-fig. 4, c_1).

The anterior spiracles (Text-fig. 4, *d*) bear 6–8 bulbs, which are arranged in an ellipse open on the inner side. The atrium is long and thin, somewhat thickening at the point of transition with the trachea. The posterior spiracles (Text-fig. 4, *e*) are entirely similar; their atrium appears relatively shorter, they bear 8–10 bulbs.

In the second instar larva only the anterior tooth of the mandiles is fully developed; the rear one appears only as a small protuberance (Text-fig. 4, c_2).



Text-fig. 4. *Phytobia pittosporophylli* Hg., Larva as in Fig. 2 (c_1 = mandibles on third instar, c_2 = mandibles on second instar).

The Mine Gall (Pl. ii, fig. 3, 4; Text-fig. 3*b*).

When this paper was being prepared, there were so many flies of this species available, which had been caught on the young leaves of *Pittosporum*, that there can be little doubt that the larvae of *Phyt. pittosporophylli* represent the producer of the mine galls which are described below, although no bred specimens were obtained. Among the flies sent to me this species was far more numerous than the previous species, and similarly the mine galls which are about to be described, and which are considered to belong to this species, occurred in considerable numbers on almost every leaf.

Oviposition takes place in spring on the young leaves. The holes through which the eggs are inserted below the epidermis are made mainly on the upper surface of the leaf, near and to either side of the midrib; occasionally oviposition punctures and mine galls may be found singly near the margin of the leaf. Oviposition punctures were already found in large numbers in the young leaves on the 27th August, 1957 (Normanhurst, leg. F. Bagshaw). The hole where each egg has been laid is surrounded by a narrow violet-brown area (apparently caused by increased deposits of anthocyan). On the 16th September (Roseville, leg. C. E. Chadwick) there were already very young larvae in the young leaves which had eaten out small channels or blotches around the point of oviposition, and these appeared somewhat lighter in transmitted light. The pustules formed in the leaf in this way increase little in size during the course of the summer. In the material from the 4th May (Roseville, leg. C. E. Chadwick) they have a diameter of 3–5 mm. which does not become larger. When the first mine galls appear in the young leaves, the pustules of the previous generation can still be found in the old leaves (Text-fig. 3, *b*); in the mine galls where the larva has developed normally and produced an imago, one finds on the lower side the large, round emergence hole. The mine galls are only slightly transparent, with a brownish discoloration, raised, and in galls which have collapsed, wrinkled. Their immediate vicinity appears darker than the remainder of the leaf surface (presumably as a result of increased anthocyan deposits), particularly on the inside of the leaf.

In sections through the mine galls in young leaves (16th September) one finds cavities which are not differentiated from those of normal mine channels. The position of these feeding channels in the leaf is extremely variable. They normally lie in the palisade parenchyma, which in *Pittosporum* consists of three layers of cells. All three layers of cells may be consumed, but often the uppermost palisade layer, or a part of it, may remain. If the mine is deeper, it may also extend into the spongy parenchyma. Calius cells are not found in these mines. These formations are nevertheless not true mines, since, wherever a feeding channel occurs, the leaf is 2–3 times thicker than normal; this immediately shows the gall-like character of these mines. In autumn the mines are already substantially larger; a section across them now shows that fairly large, tender callus cells have grown into the cavity from the spongy parenchyma which are apparently eaten by the larva. Large lumps of frass fill a large area of the cavity. If the larva has not completed its development in the early spring mines (i.e., has died) the cavity becomes filled with sparse callus cells. Plate ii, figure 3 shows, to the left of the autumn mine, a lenticular cavity which is completely filled with a few large callus cells; in Plate ii, figure 4 a similar structure can be seen to the right of the large autumn mine in which the cavity is partially empty, partially filled with callus which has pushed forward dorsally a large mass of frass.

The greatest callus proliferation occurs in the area of the mine gall adjoining the midrib, a phenomenon which can be observed in normal mines on other plants, when they form callus. This occurs as a result of the increased flow of nutritive sap in the vicinity of the fibro-vascular bundles. Oviposition in the vicinity of the midrib, as normally occurs in this *Phytobia*, is thus particularly favourable for the subsequent development of the larva.

The feeding pattern of the larva of *Phytobia pittosporophylli* Hg. thus represents a further interesting case of transition from mine to gall, already recorded for a number of species of the family Agromyzidae, and it is therefore felt justifiable to use here the term "mine gall".

EXPLANATION OF PLATE II.

Fig. 1, 2. Cross-section of shoot axis of *Pittosporum undulatum* Andr. with twig gall of *Phytobia pittosporocaulis* Hg. 1: Feeding cavity in pericycle. 2: Expanded feeding cavity of last larval instar (stain: Safranin pale green F.S.).

Fig. 3, 4. Cross-section of midrib area of leaf of *Pittosporum undulatum* Andr. with mine galls of last larval instar of *Phytobia pittosporophylli* Hg. (Stain as in 1, 2.)